Rebuilding For The Future

Safer, Stronger, Survivable

Cleveland High School, Seattle, Washington

Examples of Mitigation Successes Following the Nisqually Earthquake





Dear Colleagues:

Natural disasters are a fact of life. We know they will happen, but we don't know when one might occur or how severe the disaster will be. What we do know is that there are proven actions that can be taken ahead of time to reduce the impact of disasters.

For a number of years, Washington State and the Federal Emergency Management Agency have partnered with communities in promoting activities to reduce future disaster losses. Communities are taking action to identify their hazards. Residents and businesses have become activists in plan development, preparedness, training and mitigation.

This publication was developed to share a few of the successes that communities have had in eliminating, or at a minimum reducing, their damages during the recent Nisqually Earthquake. It should be noted that the majority of the example projects contained here were completed without Federal funds, but rather by communities establishing partnerships, using volunteers, and leveraging funds from multiple sources.

We truly believe that these success stories need to be shared. We further hope that you will be able to use these examples to communicate the value of mitigating disaster losses and promote projects that will protect lives and property.

Please contact us if we can help you with disaster resilient endeavors in your community.

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Rebuilding for the Future

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M. Patrick Yamashita, P.E., City Engineer, City of Mercer Island, WA.

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(Cover Photo: Cleveland High School, Seattle, Washington. This venerable school was built in 1909. The building has had three structural seismic upgrades. Non-structural retrofit was completed as a part of the City of Seattle School District Non-Structural Retrofit Program. This program was funded in part by FEMA's Project Impact initiative. All of the items secured stayed in place during the Nisqually Earthquake.)

Introduction

Washington State is well noted for its natural beauty of mountains, lakes and forests. It is a gateway to Canada and the many offshore recreation areas of Puget Sound and the San Juan Islands. Two mountain ranges, the Olympics and the Cascades, create a natural border for Western Washington. Growth continues at a rapid pace with population increases, new businesses, continued construction and infrastructure development. It is a desirable location in which to live and raise a family.

On a clear day, Mt. Rainier dominates the horizon. This view is from Eunice Lake. (National Park Service photo)

Washington is no stranger to natural disasters. The worst volcanic eruption on the continental United States occurred in the state when Mt. St. Helens erupted in May of 1980. Severe winter storms resulting in flooding and landslides have been frequent occurrences. Damages from these events have resulted in millions of dollars in costs and the economic loss to some locations has never been recovered. Earthquakes are a significant risk in Washington. The state is placed in seismic zone three, as determined by the United States Geological Survey. The rating of seismic zones is from 1 – 4 with 4 the highest risk.

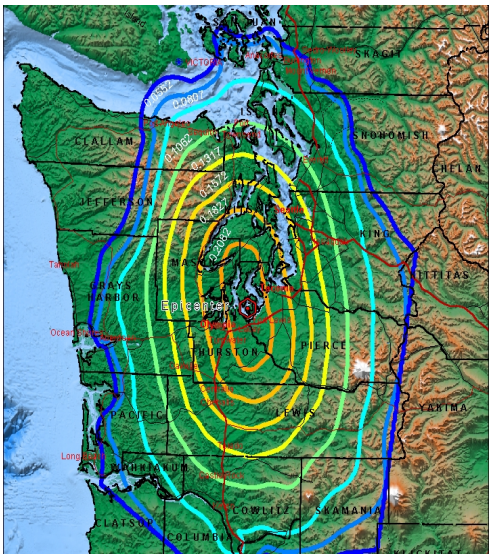
All regions of Washington State have a history of earthquake activity. Earthquakes in the state have been recorded since 1880 and more than 1000 earthquakes are registered annually. Historically, earthquake activity has been most active and damaging west of the Cascade Range. The same active geologic forces that have created the beautiful landscape also generate these earthquakes. Periodically, deep Puget Sound earthquakes occur that are strong enough to rock wood frame buildings and cause brick to fall from unreinforced masonry buildings. The area is at risk from activity of the Cascadia Subduction Zone as well as strike slip faults such as the Seattle fault.

History of Recent Washington State Earthquakes

DATE	LOCATION	ECONOMIC IMPACT
1949	Olympia M=7.1	*$100 mil to $165 mil*
1965	Seattle/Tacoma M=6.5	$60 mil plus 7 deaths
1999	Grays Harbor County M=5.8	$8.1 mil

Source: WA Military Department Emergency Management Division, 6/2000

During the morning of February 28, 2001, a magnitude 6.8 earthquake, approximately 36 miles below the surface moved the ground for a little more than half a minute. The epicenter was located approximately 50 miles south of Seattle and 11 miles northeast of Olympia in an area known locally as the Nisqually Basin. The event is now referred to as the ***Nisqually Earthquake.*** This deep slab earthquake was experienced over a wide geographical area and was felt 175 miles away in Vancouver, Canada. The ground shaking produced isolated pockets of liquefaction in all of the counties surrounding the epicenter. The earthquake caused several landslides. While the density of the quake served to reduce the overall surface damages that are likely with an M=6.8 event, there were enough injuries and damages to declare a Federal disaster. ***407*** injuries have been attributed to the quake. In all, 24 counties have been declared federal disaster areas. As of this writing, $35.7 million in aid has been spent to help Washington residents and businesses.



Nisqually Earthquake
Modeled Ground Shaking

Building Damage, Pioneer Square, Seattle, WA

Washington State has not been complacent regarding the earthquake hazard. There has been a pro-active approach to emergency preparedness and mitigation throughout the state for many years. The Emergency Management Division, under the auspices of the Washington State Military Department, has developed partnerships and programs with many private businesses and local agencies. Additionally, the City of Seattle was selected as one of the original communities to participate in the Federal Emergency Management Agency's Project Impact initiative. The results of their work became evident following the Nisqually Earthquake.

This report is a collection of Mitigation Successes that have been identified after the Nisqually Earthquake. They include examples from King, Thurston, Pierce and Kitsap Counties as well as the City of Seattle. The Nisqually Earthquake was not a catastrophic event but did produce enough ground shaking and movement to test the planning, preparedness and mitigation that has been completed throughout Washington. This series of stories will illustrate the value of this effort. The intent is to motivate the reading audience to action.

Little Church on The Prairie Learning Center

The Little Church on The Prairie Learning Center is located in Lakewood, Washington, a community of 63,790. This childcare center is licensed for up to 74 children, infants to first grade. The center maintains a full time staff of teachers, childcare providers, kitchen personnel and custodians. The daily number of children at the center is consistently near capacity.

Little Church on the Prairie Learning Center, Lakewood, Washington

Project Impact of King and Pierce counties were interested in working with day care centers to make them safer in the event of an earthquake. When the center director, Pat Ivy, was approached regarding joining the initiative she stated that she did not know the center was in an earthquake area. Following an initial discussion, an agreement was reached to organize a volunteer effort for non-structural retrofit of the center. The goal was to make the childcare center a safer place for small children when a major earthquake occurs. Any improvements would also protect the staff and create a safer place to retain all center occupants until hazards in the community were reduced before parents attempted to collect their children.

Partners for Loss Prevention, an Oregon nonprofit organization, and Project Impact of King and Pierce Counties organized the non-structural retrofit to demonstrate how childcare centers can be made safer. Puget Sound Energy and Key Bank of Lakewood supplied financial support and hot water tank strapping. A group of volunteers gathered together on a Sunday to do the work. The team secured bookcases and cabinets, anchored cribs, refrigerators and other tall objects. Members of the Pierce County Fire Marshal's Office installed protective sheathing on fluorescent light tubes.

Pat Ivy, Center Director, shows how the cribs are secured to the studs.

Protective sheathing coats fluorescent tubes.

When the Nisqually Earthquake hit the region on February 28, 2001, the children and staff of the Little Church on the Prairie Learning Center were protected from falling objects because the center had completed the non-structural mitigation of the facility. The staff describe the experience as "shaking, a loud rumble followed by a really loud rumble, it was hard to maintain balance." The teachers gathered the children under a large table and kept them together until it was safe to exit the building. Later inspection of the building revealed new cracks at the interior corner of windows in the main playroom. Obviously, the building took a shaking. The non-structural work that was done performed as expected. "Nothing fell over because of our preventative measures", states Pat Ivy, Center Director, "It was amazing." Though the center suffered some structural damage, inside there was none. And, most importantly, there were no injuries.

This project contains several successes. The objective of making the childcare center safer and stronger was achieved and then tested when the Nisqually Earthquake shook the region. The partnership of private and public entities working together for a common goal was effective and beneficial to all parties. Financially, there was minimal cost to the Learning Center as the partners donated all supplies and labor. The benefit is difficult to quantify but evident in that there were no injuries, lives lost or significant property damage.

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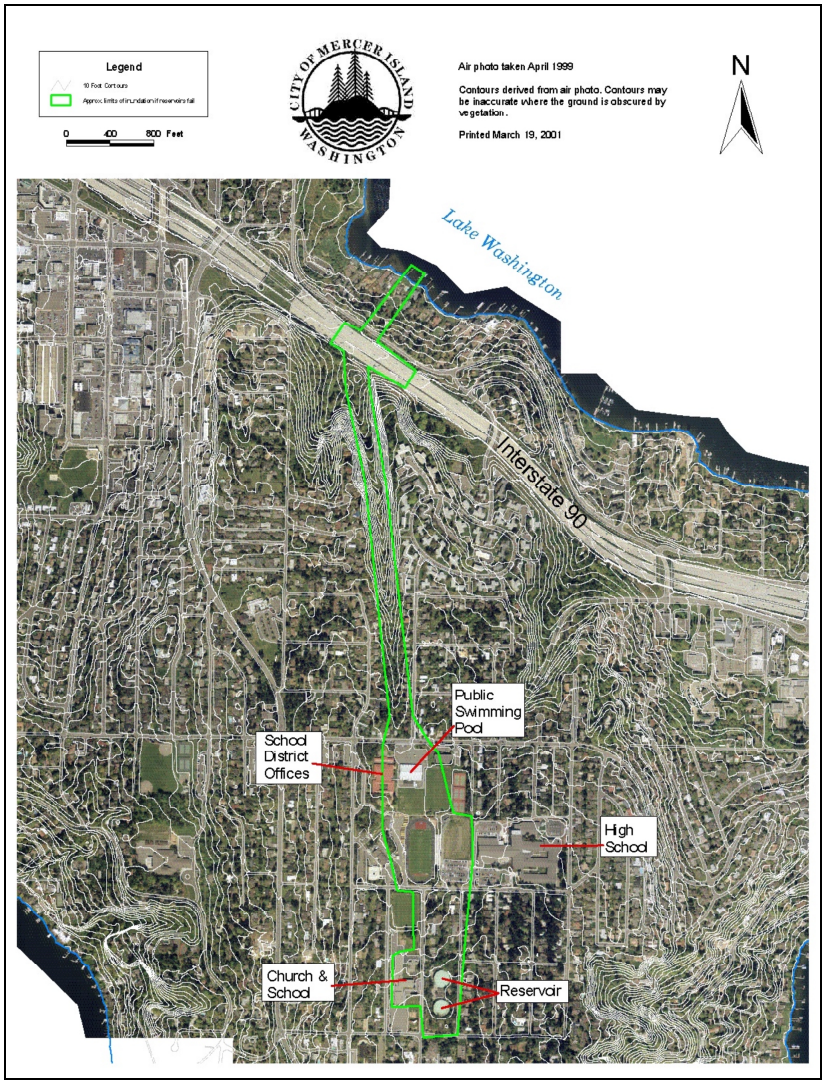
City of Mercer Island Reservoir and Pump Station

Mercer Island in Lake Washington is a busy community with a population of 22,000 and a high median income. Located east of Seattle, it is accessed only by the Interstate 90 floating bridge. The Islanders are totally dependant on two above ground steel water reservoirs, four million gallon capacity each, for their main source of water. This water supply is also essential for fire fighting.

The City of Mercer Island recognized that there was a potential life safety problem due to the fact that the island is in an earthquake hazard area. Should the tanks fail because of an earthquake, 12 homes, schools, a church and several public buildings situated downstream would be inundated. The Island would lose the primary water supply and the water flow would cover I-90, the main transportation corridor.



This aerial photograph shows the location of the reservoirs and the pathway of the water if the reservoirs failed.

The City of Mercer Island applied to the State of Washington for and was granted funding through the Hazard Mitigation Grant Program (HMGP) for seismic retrofit of the reservoirs and pump station. The HMGP is a FEMA program administered by the State. Extensive seismic restraints and structural improvements were done. Sections of the rigid pipes were replaced with flexible connections. These specially designed connections will move in the direction of earthquake activity while maintaining their integrity.

The pump station pressurizes all the water through a system of pipes that then delivers it to the upper end of the island. It was completely structurally retrofitted. Because of this critical function, restraints were installed to the emergency generator and large pieces of equipment and control cabinets were bracketed to the walls.

Customized flexible connections of pipes and strapping used to secure critical equipment.

A 6.8 magnitude earthquake struck the Puget Sound Region on February 28, 2001 at 10:54am. Mercer Island sustained a great deal of shaking. Those located close to the reservoirs during the earthquake state that the water in the reservoirs “sloshed for an hour”. The reservoirs “rode” through the earthquake with minimal to no damage and performed the way the retrofit was designed. One of the primary power poles close to the reservoir went down and caused a local power outage. The automatic generator came on line and maintained the function of the pumps without any disruption of service. The power was out for over six hours. Subsequent engineering inspection has determined that there is no threat of collapse of any of the retrofitted structures. The timely mitigation project eliminated danger to the homes and structures as well as protecting the water supply.

This project was funded through the HMGP which included federal, state, and local funding. Washington State Emergency Management Division administered the project and the work was done through the City of Mercer Island. "If we didn't have the grant funding, we never would have completed this project", states Patrick Yamashita, P.E., City Engineer for the City of Mercer Island. Project costs break out as follows:

Completed Reservoir Project

Total Project Costs: $1,386,281

Federal Share: 973,328
State Share: 162,222
Local Share: 250,732

Direct Benefits	In-Direct Benefits
Average price of homes in the Mercer Island area is $800,000. The direct cost benefit of the project is $9 million or 9:1 c/b ratio.	Avoidance of disruption and relocation of families, businesses, schools and other community activities.
Ability to continue service to the community.	Transportation system via I-90, the primary link between the Island and the mainland, not interrupted.
Preservation of water supply for fire fighting.	

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Home Earthquake Retrofit Program

Community isn't just a buzzword at the Phinney Neighborhood Association (PNA). They are in the business of building community. For 20 years, the PNA has helped the Phinney and Greenwood neighborhoods of Seattle, Washington stay healthy and vibrant by promoting a strong sense of community. Over the years, the PNA has developed a variety of activities that provide opportunities for building and sustaining connections between neighbors. Integral to the PNA is the headquarters in the heart of Phinney Ridge. In 1981, the PNA began transforming a former elementary school into what is now a well-used and well-loved community facility. The vacated school building was structurally retrofitted as part of the Seattle School District retrofit program. It is also used for childcare as well as many community programs.

Phinney Neighborhood Assn., Seattle, WA.

The Well Home Program, a non-profit program, is part of the PNA and since 1977 has provided services to Seattle homes and neighborhoods. Following the Loma Prieta earthquake of 1989, program director Roger Faris and members of the PNA decided to incorporate an earthquake safety program into the Well Home Program. In 1998, the City of Seattle was selected as one of the sites to receive disaster mitigation funds under the FEMA Project Impact program. This infusion of funds has allowed the program to expand into the ***Home Retrofit Program***, a comprehensive program to reinforce a typical Pacific Northwest home's ability to withstand earthquake ground movement.

Home Retrofit incorporates a partnership between Seattle's Department of Design, Construction and Land Use (DCLU), University of Washington (UW), Phinney Neighborhood Association, Washington Mutual Bank, Bank of America, Boeing Employees Credit Union and the Seattle Office of Housing. Each partner has contributed critical elements which make the program successful for the average homeowner:

PARTNER	CONTRIBUTION	RESULTS
Seattle DCLU	Prescriptive Planset, Checklist and Guide • Two sheet set for home retrofit projects; may be used without hiring a design professional Home Retrofit Permit • Adopted updated standards for seismic retrofitting • Streamlined process for obtaining building permits	245 Home Retrofit permits have been approved.
University of Washington Extension	• Professional training for builders and contractors • Maintains and provides a list of trained contractors	249 contractors and builders have completed the professional training.
Bank of America Washington Mutual Bank Boeing Employees Credit Union	Special retrofit loan products available to homeowners for seismic strengthening.	
Office of Housing	• Home Retrofit grants for low-to-moderate income Seattle homeowners. • Low interest loans to cover retrofit.	19 houses have been completed through the Office of Housing/Project Impact Grants
Phinney Neighborhood Association	• Home Retrofit Classes for Homeowners • Tool Lending Library	1400 have attended the Home Retrofit class

Source: Seattle Project Impact Web Page, Home Retrofit, December 2000

The Home Retrofit class teaches three basic steps that need to be taken to prevent a house from shifting during an earthquake. These are: 1) fasten framing to foundation; 2) adding framing hardware to connect walls to foundation; 3) installing plywood with proper nailing schedule and nail size to create shear walls. Homes in California that were retrofitted according to the requirements in the standard plan, as taught in these classes, remained on their foundations during the 1994 Northridge Earthquake in Los Angeles. Essentially, the method was tested at that time. These measurers, when applied correctly, meet the minimum building code requirements for seismic safety in the City of Seattle.

A unique feature of this highly successful program is the Tool Lending Library. "Half of doing any job well is having the right tool, and we have hundreds of tools to help you do

that job right", states Roger Faris, Well Home Program Director. PNA members can borrow tools for a modest weekly tool maintenance fee, and in some cases, at no cost. Having the right tools readily available for homeowners use provides additional incentive for retrofitting homes.

Benefits of a Home Retrofit program are many:

- Safer Homes – implementation of the standard plan results in stronger homes that better protect the lives of the building occupants.
- Lower Repair Costs – previous earthquake damages have resulted in an average cost for home repair of $25,000 to $35,000 plus the average cost of a licensed contractor to do the work of $2,000 to $4,000. The cost of homeowners to do the work themselves is generally $1,000.
- Less Damage to Utility Connections – preventing building shift reduces the likelihood of displacement of gas, power and water service connections.
- Availability of Home Retrofit Loans – protection of property investments.
- Improved Chance of Obtaining Earthquake Insurance – many insurance companies require common structural weaknesses to be strengthened as a qualification for earthquake insurance.

Models used by Roger Faris for the Home Retrofit Program

When the Nisqually Earthquake struck, Roger Faris recalls the thoughts that went through his mind as he was crouched under the table. ***"I thought about what we had taught, what we had done to retrofit homes, what kind of hardware we used and would it work. Although the type of shaking wasn't enough to give it a good test, I have received many calls from 'graduates' stating how secure they felt that they had retrofitted. One man was home ill, he just smiled and felt good that he had done the work."***

To encourage other Washington communities to learn from this successful Seattle program, building departments outside of the city have joined discussions to expand the Home Retrofit Program regionally to their jurisdictions. This expansion effort will continue the implementation of consistent, effective mitigation measures. Clearly, community programs partnering with private and public agencies create a successful formula toward building disaster resistant communities.

Private Home: Seismic Construction

The process of building their dream home began for Dick and Carol Heavener with the purchase of house plans. The first stage of building began with help from the Olympia College Skill Center who came in and did the entire framing without charge.

Carol Heavener, who works at the local fire station, found out quite by accident that the property their home was being constructed on was considered a "trouble area". "There's a lot of clay on hard-pan, which could cause excessive movement in case of earthquake," she said. Carol and Dick figured it would be at least an 80% savings to add seismic strengthening measures into their design plans from the beginning than do retrofitting after construction. A new set of plans, which included the seismic measures, was developed.

Because of the 45-degree angle of the house, special "one piece" ties were designed with brace supports for the columns in all of the beams. Special connectors were specifically designed with splits and made stronger to accommodate the angles in the house. This technique was repeated throughout each level with the use of anchor plates and strap ties strategically installed for added reinforcement.

Special fabricated steel column cap connections that fasten beams to columns. These fastenings prevent shifting of the structure during earthquakes.

Construction incorporated bolted steel plates and strap ties throughout. This system "ties" beams and columns of roof and walls together to maintain structural integrity.

Twice earthquakes have tested this beautiful home, which sits on the banks of Puget Sound in Western Washington. In 1998, while Dick was doing some work in the house,

using a dangerous saber saw, a moderate 5.5 rumbler came through. Carol felt it, but Dick felt nothing and the house did not move. Then again on February 28, 2001, a strong 6.8 earthquake struck the area causing widespread damage. Glass jars on shelves full of nuts, nails and bolts didn't move, nor did the dishes. Nothing fell or broke, everything stayed in place. Many chimneys in the area were damaged, but the Heaveners' did not move. The retrofit measures were tested and passed without a hint of damage.

When asked if any more safety measures will be added before completion, Dick said "a built in generator system will be added to ensure no total loss of power."

Market value of this home, when completed, is estimated at $400,000. ***The value of their security from knowing they have a seismically sound house: priceless!***

Heavener Home, Poulsbo, WA

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Rainier Manor Mobile Home Park Retrofit

Most elevations are completed.

Rainier Manor Mobile Home Park with its 75 plus homes sits in a "bowl," if you will, on the banks of the Puyallup River in King County (Sumner), Washington. In 1995, because of excessive spring rains and an early snowmelt in the mountains, a nearby levy overflowed, flooding over half of the homes that were situated in the lowest parts of the mobile home park, and within the confines of this "bowl." Most of the mobile homes were destroyed or severely damaged to more than 50 percent of their value, exceeding the 50 percent rule of the National Flood Insurance Program (NFIP). This initiated a visit by an NFIP agent.

The agent discovered that the residents were not following any type of standard in their recovery efforts. This prompted the agent to persuade the city to support and enforce regulations in order to maintain their eligibility in the flood program. Residents, all retired and on limited incomes, became upset when notified that they were in violation of the regulations. Because of the expense of meeting code requirements, the homeowners argued for and won a variance.

The NFIP, along with the Small Business Administration (SBA), set up a Reconstruction Information Center (RIC) in the mobile home park to educate and convince residents to not only elevate for flood, but to do seismic retrofit for earthquake at the same time. Severely damaged homes were eligible for replacement. A team of counselors were provided to make individual counseling available to each homeowner. The homeowners were shown renderings of what their homes might look like, and the counselors assisted in going to dealers in the area to find the best prices for new mobile homes.

To help lessen the expense for the homeowners, a mission assignment was developed with the US Army Corps of Engineers (USACE), to do individual surveys to determine the elevation necessary for each individual home.

All of the homes in the mobile home park had been improperly set-up. A video was produced through the Hazard Mitigation Technical Assistance Program (HMTAP), which illustrates the proper installation methods. New standards were developed and are used today to educate dealers and all stakeholders, from transporting to set-up and installation of mobile homes.

Sandbags still line the banks of the Puyallup River that flows by Rainier Manor Mobile Home Park.

New seismic bracing standards had to be incorporated with the best methods for securing mobile homes to their foundations.

The combination of individual insurance and Small Business Administration (SBA) loans provided adequate funds for elevating and retrofitting every home that was destroyed or damaged in the Rainier Manor Mobile Home Park.

A 6.8 earthquake struck the Puget Sound Region on February 28, 2001. Not one home sustained any damage. Accompanied by George Currin, one of the original NFIP agents, we visited several of the residents, who were happy to report no damages occurred during the earthquake. One delightful lady said she had just made lunch, but her husband was asleep in his chair, so she decided to leave him there. When the earthquake hit, "he came flying out of that chair, but not one thing fell or came out of place."

The success of this story is not only the fact that no homes were damaged from the earthquake event, but that six years ago the agents from the NFIP and SBA turned an otherwise disastrous situation into a positive result. Their patience, guidance and assistance created a safe environment for every resident in the Rainier Manor Mobile Home Park.

New mobile homes with multi-hazard protection: elevated against flood and seismically bolted/strengthened against earthquake.

The cost per home for replacement averages $40,000 with an additional $10,000 to $15,000 to elevate. This is a one-time investment and avoids the potential future cost of repetitive damages, family disruption or re-location.

Seattle School District: Non-structural Retrofit Program

The Seattle School District has been aggressively pursuing creating a safer environment for their students and faculty for many years. Earthquake safety for schools has been an ongoing objective even though there is no state requirement that school districts implement programs to improve the earthquake safety of school buildings. The school district had already experienced two major earthquakes, 1949 and again in 1965. Substantial damage to both public and private schools as a result of these earthquakes heightened awareness of the vulnerability of state schools, particularly those older buildings of unreinforced masonry.

History of Earthquake Losses to Washington State Schools

YEAR	PROPERTY LOSSES	CASUALTIES	COSTS
April 1949	• 30 schools closed • 10 condemned	Two students killed by falling bricks	Total loss: $60mil • repair and replacement costs $28mil (1998 dollars)
April 1965	• 8 schools closed • 2 severely damaged	None reported	Total loss in excess of $60mil (1998 dollars)
February 2001	• limited school closure	None	*(not available at the time of this report)*

Source: Safer Schools Earthquake Hazards Non-structural, Lessons Learned Seattle School District, November 2000, Second Edition, Noson & Perbix

In Western Washington, a number of school districts are strengthening their buildings to improve student safety in response to the known earthquake hazard and to concerns expressed by district managers, teachers and parents. The Seattle Public School District embarked upon a series of building evaluations, facility utilization studies and seismic evaluations over the period of 1960 to the mid-90's. By 1998 the district was in the final phase of a multi-year capital improvement project to seismically strengthen their buildings. To date, a total of 101 schools and district buildings have been structurally retrofitted.

Currently, the Seattle School District is implementing a program of non-structural retrofit for all of their schools. Seattle Project Impact, through FEMA, funded this program. The Seattle Public Schools Project Impact program includes removal of overhead safety hazards, evaluation of automatic seismic gas shut-off valves, updating of the School Earthquake Hazard Reduction Manual and implementation of a district wide non-structural mitigation program.

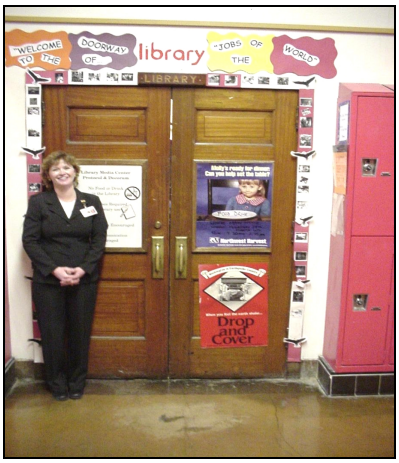
Funding Sources: Seattle Project Impact (FEMA) $400,000
Seattle Public Schools $100,000
In-kind contributions by district staff, volunteers & partners

The decision to implement the School Non-structural Earthquake Protection Program incorporated general safety elements necessary for schools, as well as earthquake hazard reduction. A process for program implementation was created that included developing basic guiding principles to set direction and a course of action. Program steps were established which include:

- define the school district's goals and identifying responsibilities;
- obtain school district support and commitment;
- identify, coordinate and manage the expertise that is needed to complete program activities;
- train district maintenance, facilities, safety and security staff;
- complete an inventory of school building spaces for non-structural earthquake hazards;
- utilize completed inventory forms to prepare work plan;
- select and implement non-structural earthquake protection measures using information in the *School Facilities Manual Non-structural Protection Guide;*
- monitor and track all program activities.

Using this process, a cost effective, comprehensive program soon emerged that combined existing resources, volunteers and several innovative approaches. The goals of creating a safer environment for all occupants of the school district buildings were also met.

The inventory served to identify and prioritize specific non-structural measures. A wide variety of measures have been completed. One of the first activities was to remove all the outdated overhead wastewater reservoirs that were located in school attics. An evaluation was done regarding automatic gas shut off valves. Some were installed in those schools with identified gas hazards in laboratories and shop areas. Display case strapping, securing of book cases, audio visual equipment and library shelves; securing of desk top and counter top equipment such as computers, aquariums and microwaves; securing of



Theresa Salmon
Special Projects Administrator

Library computer equipment strapped in place.

ceiling light fixtures, wall mounted speakers and sound systems; securing heavy floor mounted equipment such as drill presses, vending machines and large shelving units has been completed in several schools to date. Safety film has been installed on interior glass.

When the Nisqually Earthquake struck on February 28, 2001, all schools in the Seattle School District were shaken. The students and faculty knew what to do because of the annual drills they had conducted and emergency preparedness plan reviews. There was enough ground motion to trip the gas shut off valves. Structural damage was minimal compared to the losses suffered in the past two significant earthquakes. Several teachers sent memos to Theresa Salmon, Special Projects Administrator thanking her for the non-structural measures that were implemented in their schools and shared how well everything performed.

> ***"Just wanted to let you know the good news on how well Mercer (the building) did during the earthquake—and a big thanks for the retrofitting. We did not even have a single light cover come down, a computer fall over, a book come off a shelf. Now, how do we get more straps to do the new things we have installed since retrofitting was done here. Think you have made believers out of us!" wrote a school nurse. Another comment, "Great! Everything shook but nothing was out of place."***

This recent experience has tested the program and proven that the results are well worth the effort. There are many successes and innovative approaches that demonstrated the value of pursuing structural and non-structural safety measures. Of note is the relatively low cost by using existing personnel, partnerships, students and in-kind services. To quote Theresa Salmon, ***"The most expensive item in the program are the computer straps. We had the students install them as part of their school curriculum which avoided high labor costs. Simple approaches are effective."***

Seattle, WA, March 11, 2001 -- Pre-earthquake mitigation prevented greater damage to the Seattle public schools. A gas valve was mitigated to prevent gas leaks following earthquake.

Bracing of overhead spotlight.

Bookshelves secured prevent tipping over into exit.

Private Home: Structural Retrofit

In late 1998, Mrs. Doris Chapot, a delightful and very spry 80 years young, made the decision to leave California and move to historic Poulsbo, Washington. She found the home of her dreams, and for $190,000, purchased a quaint two-story Cape Cod style home that was built in 1902 and, for years, served as the First Lutheran Church parsonage. In 1940 the parsonage was moved to its present location. An effort was made to reduce future earthquake damage by placing the house on posts and concrete blocks.

At the time of purchase, a building inspector had mentioned to Doris that she should have an earthquake retrofit done to ensure that there are positive connections among beams, posts, and pier blocks. Being married to a building contractor herself for many years, and coming from earthquake country, Doris knew that was good advice, however, because of an illness, it took her nearly two years to take any action.

Finally in late February 2001, Doris made the call to Northwest Renovations. Normally they would be booked up at least a month in advance, but due to a delay with another subcontractor, they were able to fit her project into their schedule without hesitation.

Mr. Rich Reidesel, master carpenter for Northwest Renovations, was assigned to work on Mrs. Chapot's home. Piers (40) were braced with a gusset system that included 2 ft. triangle shaped plywood tying the posts to the concrete pier. All of the posts around the perimeter were tied together in the front and the back with 2X6 posts and nails were strategically placed. Because pier blocks were different shapes, bendable metal connections were used for attaching the posts. ***"Rich went the extra mile!"*** stated owner/operator Bill Hudson. ***"The house feels solid now,"*** stated Mrs. Chapot.

The retrofit project was completed on Monday, February 26, 2001, at a total cost of $3,312. On Wednesday, February 28, a 6.8 earthquake occurred, with the epicenter located in the Nisqually Basin in Washington State. Movement was felt as far north as Vancouver, BC and as far west as Salt Lake City, Utah. The quake resulted in several million dollars of damages.

Ironically, on the day of the earthquake, Mr. Reidesel was scheduled to obtain the final payment for the retrofit work done on the Poulsbo home. Doris greeted him with a beaming smile and said that she had been on the second floor during the quake. ***"I've been through many earthquakes during my lifetime and the house rode beautifully. Not one thing in the house fell or broke!"*** After a careful inspection under the house, not even a hint of damage was detected.

When asked what she felt was the most important benefit, Mrs. Chapot stated, "the safety of my dog and myself, everything else can be replaced. ***It feels so good to be safe."***

Private Home: Non-structural Retrofit

Living in earthquake country is taken seriously by the owners of this home in the Montlake District of Seattle, Washington. One of the owners is an Emergency Preparedness Instructor for the City of Seattle and the other conducts a busy speech therapy practice from their home. The combination of having clients, many of them children, and the need to "practice what I preach" was a strong motivator for installing non-structural methods throughout the house. Additionally, there are many expensive art items and family pieces that would be irreplaceable.

Materials used were cabinet latches, three different types of brackets, water heater strapping and flexible gas lines, museum wax and quake hold putty, lag screws and "curling" picture wire. The cost of the materials was approximately $300 and installation was easy.

The following photographs are from their home and demonstrate the non-structural items in place. It is of interest to note that there are very few visible brackets and they do not distract from the overall beauty of the interior. Also, material used to secure delicate items to shelves does not damage the item or the shelf.




This hutch is a homemade piece and valued by the owners. It is secured to the wall studs with interior lag bolts. All of the decorative items are secured with museum wax or quake hold putty. Hutch and kitchen cabinets have push and release cabinet door latches and shelf guard on the inside shelves. The television is placed on quake matting. The only item that fell during the February 2001 quake was one of the small Matruska dolls.




Three types of brackets were used to secure filing cabinets and shelving units. Heavier brackets were used for the filing cabinet because of the weight of the contents. The taller shelves in the family room are bracketed and the china dolls are secured in place with museum wax. The water heater is secured with metal strapping wrapped around the heater and fastened to wall studs. Flexible tubing for the gas lines replaced the standard tubing.

This home exemplifies simple and effective ways for protecting property and preventing injury. The small dollar amount invested was returned many times just in peace of mind.

Lake Washington School District Seismic Upgrades

It was April 29, 1965 when the last major earthquake struck in western Washington. While aware of the possibility to have another event, locals had been lax in their efforts to secure properties and buildings.

With population growth over the years, building of more schools and existing schools getting older in the Lake Washington School District, district staff and parents were concerned about the possibility of earthquake and what would happen to their children in such an event.

In early 1992, the school district secured the services of local engineers to look at school buildings to assess the seismic safety of each one. The assessment sorted needs into either structural or non-structural projects. The result was a matrix of projects that was prioritized and calendared over a number of years. An incremental solution was necessary since schools depend on local dollars to fund capital projects and all the seismic projects could not be funded at the same time.

The issue was addressed with great enthusiasm, prompting the school district, which includes Kirkland, Redmond and parts of King County Washington, to impose a construction levy on the 1992 general election ballot to raise funds for seismic upgrades, a safety program, and also an Americans With Disabilities Act (ADA) program. A two year levy was initiated in 1996 and a four year levy in 1998 with total funds, for retrofit alone, in the amount of approximately $5 million. Since the funds are issued in six (6) month allotments, the focus was on structural seismic projects and then non-structural mitigation in the buildings. All projects to date are complete, with the latest just finished in the summer of 2000.

On February 28, 2001, mitigation and safety measures in the Lake Washington School District were put to the test when a strong 6.8 earthquake struck the Nisqually Basin and Puget Sound area of western Washington State. Forrest Miller, Director of Support Services for the school system says, ***"The buildings were all tested and nothing failed. The only building issue was one light fixture that fell in the oldest building, built in 1952, and approximately $280,000 in superficial damages."***

Ironically one of the teachers had told the children there would be an earthquake drill sometime "today." When the real earthquake struck, one child said, ***"How'd you make it feel so real? Can you do it again?"***

There are several successes to this story.

- Mr. Miller stated he is "impressed with the people in this District who got things done!" Because of their support, foresight and perseverance, injury was avoided and millions of dollars were saved.
- Because of their on-going safety drills, the children and teachers were well trained, and in some cases, were actually telling some of the adults what to do.
- Custodians and other appropriate employees have received the Applied Technology Council (ATC) Training, which teaches *rapid visual assessment* of

structures. Immediate inspection can be done after an incident, which, in this case was instrumental in allowing classes to resume with minimal loss of time.

- Teachers and other school employees were tested beforehand to determine responsibility during earthquake and fire drills so every student and staff member would be accounted for and in their pre-determined location.
- Parents feel their children are safe and well trained.

The benefits to this story are many. There are 25,000 students in the Lake Washington School District, which is the fifth largest in the state of Washington. There was no loss of life or injury, and 40 buildings in the district were saved from earthquake harm by either new construction or seismic retrofit. To construct a new school building today would cost at least $50 million, and to find temporary housing for classrooms in case of damages would have cost thousands.

This is an exemplary case of being prepared through efforts prompted by concerned parents and staff members. The overall success combines continuing emergency preparedness training, funding through a community tax levy and implementation of mitigation techniques. The investment is lifesaving and creates sustainability.

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Critical Waterline Seismic Retrofit

Holmes Island lies within the waters of beautiful Long Lake in western Washington State. Less than 30 homes are on the island, with only one road and bridge for access and one pipeline for its water source. That waterline follows along Holmes Island Road and across the bridge.

In the summer of 1995, a project was undertaken by the City of Lacey, Public Works Department. Approximately 200 feet of pipeline was replaced on each side of the bridge and across totaling 450 foot. Flexible joints were designed to rotate, extend, retract and twist connecting high- density 8" sleeved polyethylene water main pipes that were run through 10" steel pipes for extra protection. The total cost for this project, funded through the Water Utility Funds for Capital Improvement, was $162,000.

In the event of earthquake these pipes will move along with the bridge, and avoid rupturing, which would cause loss of water to the island, and thousands of dollars in repair. "It would cost $4,000 for one coupling alone," states Mark Russell, Design & Construction Manager for the City of Lacey, Public Works Department. "A temporary system would cost $15,000 to $20,000."

The Holmes Island Bridge and waterline were tested on February 28, 2001, when a strong 6.8 earthquake struck the Puget Sound Region of western Washington.

Approaches to the bridge slumped 6-12", and bridge supports were pulled away from the banks. The ground all along the road moved at least that much. The water main pipes dropped 8". Because of the flexible expansion capability of the waterline under the road, no pipes were broken and water supply was never compromised.

View of bridge disruption.

Flexible joints prevented rupture of the waterline.

The City of Lacey is currently seeking $50,000 in federal funds to replace a portion of the waterline that is out of alignment from the earthquake. Had the city not planned ahead, they could have spent up to $20,000 for a temporary "fix" as well as an additional $162,000 or more for a new pipeline. More importantly, the residents of Holmes Island did not lose their water source, and now have reassured confidence that their lives will not be compromised from loss of water.

Health Care System: Structural and Non-structural Upgrades

Group Health Cooperative (GHC) of Puget Sound is a large health maintenance organization throughout Washington State. The system includes several facilities that are either owned or leased by the cooperative. The function of the buildings includes acute care hospitals, assisted living facilities, medical clinics, specialty centers, administrative and support centers. GHC is also a major employer in the state.

Following the Loma Prieta earthquake of 1989, Aubrey Davis, then President and CEO of GHC, resolved to bring the organization up to the highest standards of emergency preparedness and mitigation. The goals were to provide a safe environment for patients, visitors and employees, and to have the ability to continue delivering health care following a natural or man-made disaster. To meet these goals, the Department of Emergency Preparedness, Safety and Security was formed within the Administrative Services Division. This department was tasked with reviewing the existing emergency preparedness plans and creating a long term plan to meet the goals. Included with the project was partnering with the Facilities Services Department to plan structural and non-structural upgrades for the built environment.

The Emergency Preparedness Program incorporates, in part, emergency response plans for each facility, a regional approach for response, a corporate response plan and an Emergency Operations Center at the GHC administrative location, coordination with the various county Amateur Emergency Radio Systems (ARES), training, structural and non-structural upgrades for buildings. One of the most significant elements of the program is the outreach to employees and their families. The belief is that when the employees' families are prepared and safe, the employees are more comfortable staying or reporting to work. Health care is the GHC product and the members as well as the general public expect the services to be available at times of crisis.

The investment in the GHC Emergency Preparedness Program has been tested many times. There have been incidents of civil unrest that have required certain buildings to close and the emergency response plan to be activated. There have been chemical leaks. There have been severe winter storms that have caused power and communication outages. There has been a 6.8 earthquake.

"Timing is everything", stated Bill Biggs, GHC Director of Administrative Services. When the earthquake struck at 10:54am on February 28, 2001, it was a business day morning. All of the executives (decision makers) were at the corporate offices. They were immediately able to assemble and activate the emergency operations function. Within minutes after the shaking stopped and the immediate assessment of their building was completed, the facilities call center was established, building assessments initiated and resources mobilized.

Communications were by phone and radio. Facilities engineers and maintenance personnel in the clinics and hospitals had building assessments completed and reported within 30 minutes after the earthquake. Throughout the organization there were several instances of damage or service interruption. There were elevators out of service, power

outages at the Olympia and Lynnwood Clinics and a chemical leak at the Northgate Clinic. Two buildings, one in downtown Seattle and one in Tacoma, required evacuation and were shut down for a 24 hour period for inspection.

GHC Central Hospital, located on Capitol Hill in Seattle, experienced severe shaking but sustained no damages. This building is comprised of a set of wings, all built at different times ranging from 1959 to 1970. In 1995, a major seismic upgrade project was completed on the older wings of the hospital. The project consisted of the addition of shear walls and internal seismic bracing. The project cost was approximately $1.2 million. This is but one element of the total investment that GHC has made to meet the original goals of making a safe environment.

Many non-structural methods have been incorporated into the various facilities. All of the pharmacies, including the pharmacy warehouse and distribution center, have quake matting on the shelves. Nothing fell off the shelves during the February earthquake. The racking system for network components is secured with bracing and bolted to the floor. Everything stayed in place. Safety film was installed on windows at the day care center in downtown Seattle. The building was stressed enough to produce new cracking but no windows were broken. Those offices that had reversed their overhead shelves reported that none of the items such as large reference books and binders fell off during the shaking. Ceiling light fixtures that were earthquake wired did not fall.

The Hospital Incident Emergency Command System (HIECS) worked very well where implemented. There was an orderly, campus-by-campus assessment and reporting. Collecting accurate and timely information is essential to decision making and maintaining operations. The investment in training of personnel to this system paid for itself by avoiding unnecessary time loss.

Lessons were learned during the earthquake that will be incorporated into future training:

> ***"The behavior of employees at the time of the earthquake was troublesome. Many were watching out of the windows. Clearly, Drop, Cover and Hold, needs to be reinforced. Our teams will be reviewing procedures. We need more leadership and standard roles. In spite of these things, our planning and mitigation efforts have paid off. There was minimal service interruption and no system failures."***

GHC is a health care organization but it is also a business. The preparedness and mitigation programs that have been undertaken were initiated from both a humanitarian and financial perspective. Planning and training have served to ensure the continuation of services to all members of the community. Investment in structural and non-structural "fixes" also ensures the continuation of services as well as reduction of business loss.

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City of Seattle Police Dept: East Precinct Structural Retrofit

The old building on 12th Street, in Seattle WA, built in 1926, was for sale *as is* in 1985 with an appraisal value of $2.3 Million. Originally an auto dealership, then later a major taxidermy, the city offered a proposal to purchase the building to become it's newest police department.

Early in the 1990's the city decided to do an overall survey to determine the weaknesses and integrity of several older buildings. This one was one of the worst. A project to strengthen and seismically retrofit the building began in August of 1995 and was complete in January of 1998. Capital Improvement funds were used to fund the project, at a cost of approximately $957,000.

Diagonal bracing was done on the east and north walls of the 1st and 2nd floor, and on the same walls of the basement. One major brace was run through the middle of the building while extra members were strategically placed throughout each floor. Certain walls have been reinforced with fiberglass and epoxy.

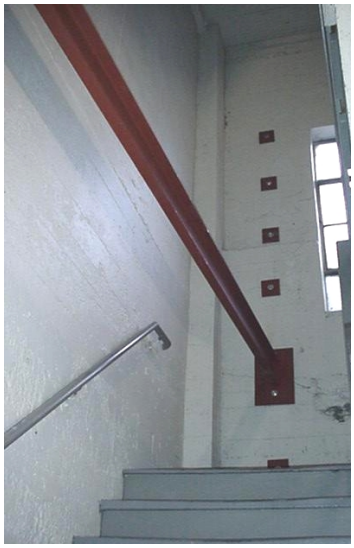
Structural retrofitting is continuous throughout the three levels of the building, diagonal and vertical.

In the basement micro piles were driven into the footings and additional diagonal and vertical braces were installed to pick up the load if the building should move. Steel angles connect the floors and walls. A new emergency generator system was installed using bolted footings with springs that allow for earthquake movement without disrupting the equipment.

Many member supports add additional strength to the eight bays of trusses lined in a series across the roof of the building. Windows throughout the building have been

covered with safety film. “This was a difficult job that took over a year to complete,” states Robert Snyder, City Architect and Engineer for the project. “The police department remained active throughout the retrofit.”

The southwest corner of the East Precinct has always been a weak spot. When a 6.8 earthquake struck the Puget Sound Region of western Washington, the integrity of that corner, which is also an exit stairway, was seriously compromised. Temporary steel braces were added to secure the walls, as well as vertical reinforcements bolted through from the outside.



The earthquake “really rocked the building,” stated one police officer. “It was very strong!”

Visiting several departments throughout the police department, we found no one who experienced any non-structural damage. “Some phone books fell over, and some file drawers came open,” stated one of the employees.

There were a few cracks in the safety covered windows, that would have shattered had the film not been applied. Up on the roof the scupper shifted causing leakage though the seams and into the interior of the building. By this happening it was obvious the movement from the earthquake was very strong.

Thanks to the City of Seattle for their proactive decision to fund the retrofit project, lives were saved, injuries avoided and the critical facility remained operational. Even though there was some damage, the historic and valuable seventy five year old building was saved from total collapse.

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Conclusion

The Nisqually Earthquake is not considered a catastrophic event, however, injuries and damages did occur. Major transportation routes have been interrupted, most notably the Fourth Avenue Bridge and Deschutes Parkway in Olympia and the Alaskan Way Viaduct and Magnolia Bridge in Seattle. Business and government services have been impacted. Federal and state agencies have approved $35.7 million in aid to help Washington residents and businesses, as of April 13, 2001. This earthquake has served as a major "wake up call" regarding the seismic hazards throughout western Washington. It has also served to demonstrate the value of pro-active planning, preparedness and mitigation.

Mitigation matters, as illustrated in the collection of successes included in this report. Actions that are taken to reduce or eliminate the long-term risk to human life and property from natural hazards are known as mitigation measures. A variety of structural and non-structural mitigation measures or solutions have been described. These are intended to motivate the reader to take action. Additionally, several sources of funding for public or private projects have been described.

The Puget Sound Region is a highly desirable area and continues to experience population growth and attract new business. It is also subject to natural disasters. Community leaders have been actively implementing mitigation measures in the region and the benefits of this work became clear following the Nisqually Earthquake. Several critical elements came together to protect the community, such as:

- Retrofitting of transportation systems.
- Retrofitting of buildings and public structures.
- Business and school planning.
- Training and public education.
- Establishing and enforcing seismic building codes.
- Creating private /public partnerships.
- Utilizing volunteer and in-kind resources to implement programs.
- Private, corporate, public and legislative funding sources.

Creating a safer environment in which to live, work and play does not have to be overwhelming. It can be financially feasible. Understanding the risks and hazards is often the first step towards effective preparedness and mitigation programs.

Mitigation Information available on the Internet:
Federal Emergency Management Agency (FEMA): www.fema.gov
WA State Emergency Management Division: www.wa.gov/mil/wsem
United States Geological Survey: www.usgs.gov
University of Washington Geophysics Program: www.geophys.washington.edu
Western States Seismic Policy Council: www.wsspc.org
Cascadia Regional Earthquake Workgroup: www.crew.org

For additional information call:
FEMA Region X regional office at (425) 487-4600
WA State Emergency Management Division at (253) 512-7000